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J_C control by hybrid pinning of nanorods and nanoparticles in $YBa_2Cu_3O_{7-x}$ film

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Improvement of critical current density (J_C) and suppression of J_C anisotropy are required to develop high performance $YBa_2Cu_3O_{7-x}$ (YBCO) tapes. While introduction of nanorods comprising of $BaZrO_3$, $BaSnO_3$, $BaHfO_3$ is effective for improving the J_C in magnetic fields, the nanorods result in anisotropic vortex pinning and significant J_C anisotropy. The J_C anisotropy should be reduced with maintaining high J_C in YBCO films. For this purpose, we prepared the YBCO films containing nanorods and nanoparticles to realize hybrid pinning, and investigated influence of the nanorod and nanoparticle distributions on J_C.

YBCO films were fabricated on $SrTiO_3$ substrate by PLD (Pulsed Laser Deposition) method. Here, BHO nanorods and Y_2O_3 nanoparticles were incorporated using the 6wt%BHO-doped YBCO target and Y_2O_3 sectors on targets (pure YBCO/YBCO+BHO targets), respectively. We prepared two types of samples of YBCO+BHO+Y_2O_3 films and YBCO+BHO/YBCO+Y_2O_3 films in addition to the YBCO+BHO single layer film (SL). The superconducting properties of fabricated samples were evaluated at 77 K, 65 K, 40 K and 20 K in magnetic fields.

At 77 K, the YBCO+BHO single layer showed F_{PMAX} = 25.1 GN m^{-3} (77 K, 5 T) which was higher than that for the YBCO films containing both nanorods and nanoparticles. However, at 20 K, F_{PMAX} = 806 GN m^{-3} (20 K, 12 T) which was the highest at 20 K among the present films was obtained in the YBCO+BHO+Y_2O_3 film. The J_C minimum was observed at 40°, and the J_C minimum was 1.67 $MAcm^{-3}$ and 3.58 $MAcm^{-3}$ for the YBCO+BHO+Y_2O_3 and the YBCO+BHO in a temperature of 20 K and a magnetic field of 16 T, respectively. The in-between value of 2.32 $MAcm^{-3}$ was observed for the YBCO+BHO/YBCO+Y_2O_3 films. By tuning the distribution of nanorod and nanoparticle, the J_C values and J_C anisotropy can be controlled in YBCO films.

Keywords: voltex pinning, YBCO